



Top quark mass in dilepton and all jets channels

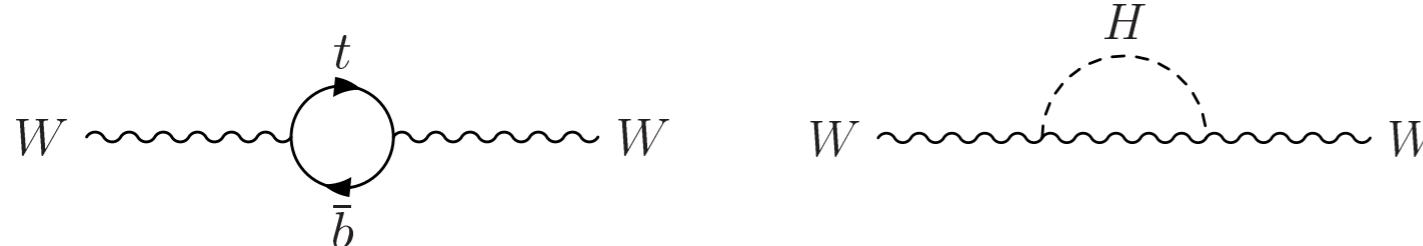
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On Behalf of the CDF and DØ Collaborations

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Why measure the top mass?

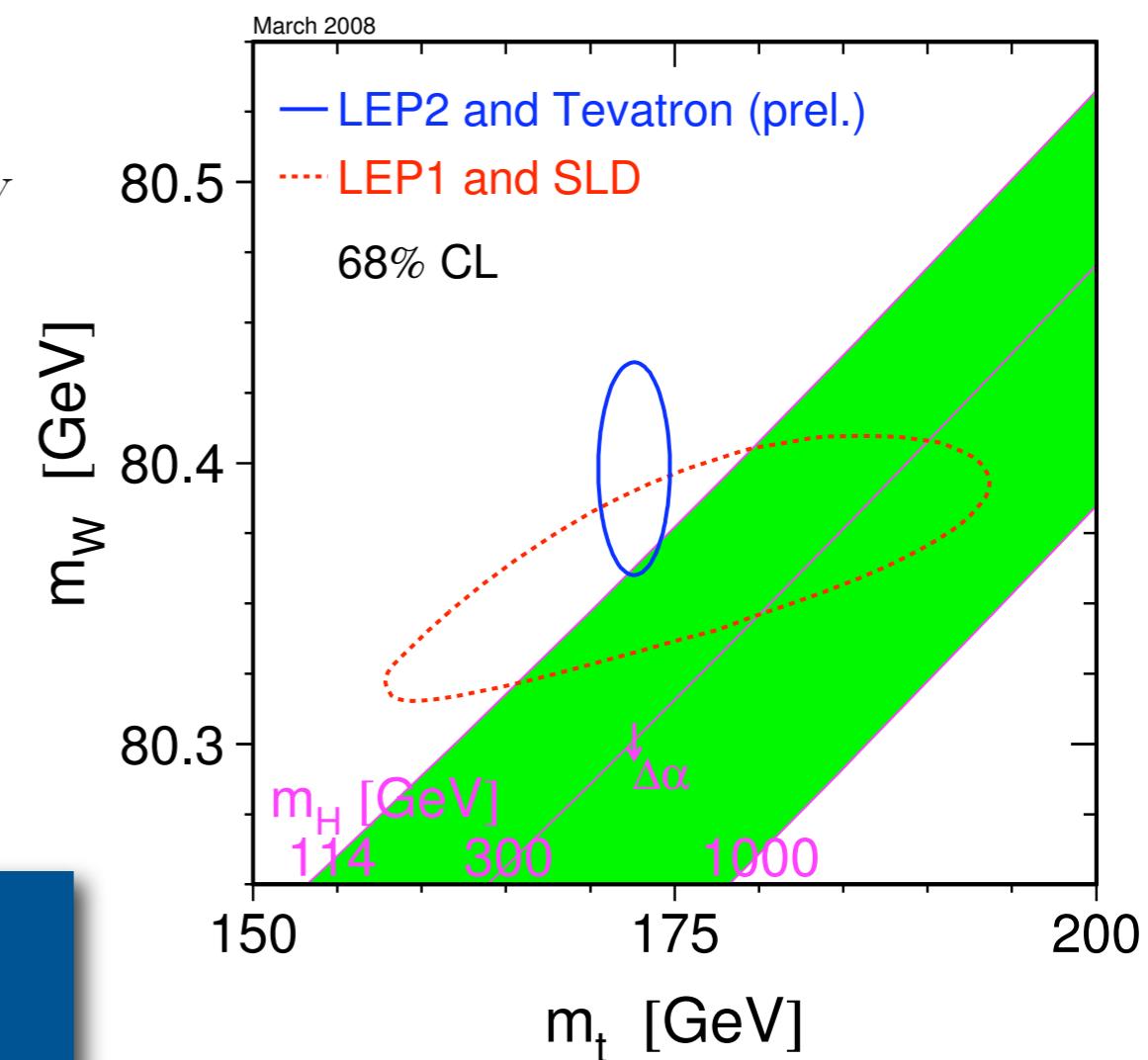
- Top mass is a fundamental parameter in SM
 - Important in radiative corrections



- Why so massive?
 - Only fermion with mass near EW scale
 - Yukawa coupling of ~ 1
- Constrains SM Higgs mass and SUSY models

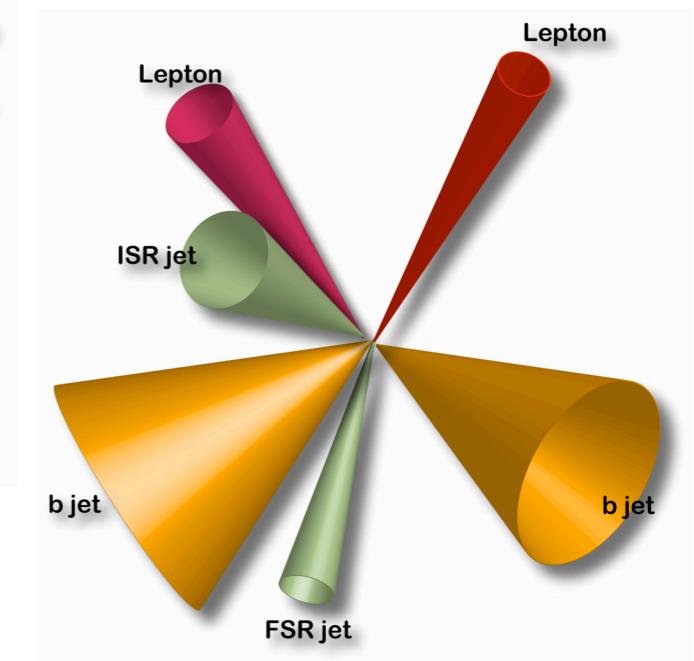
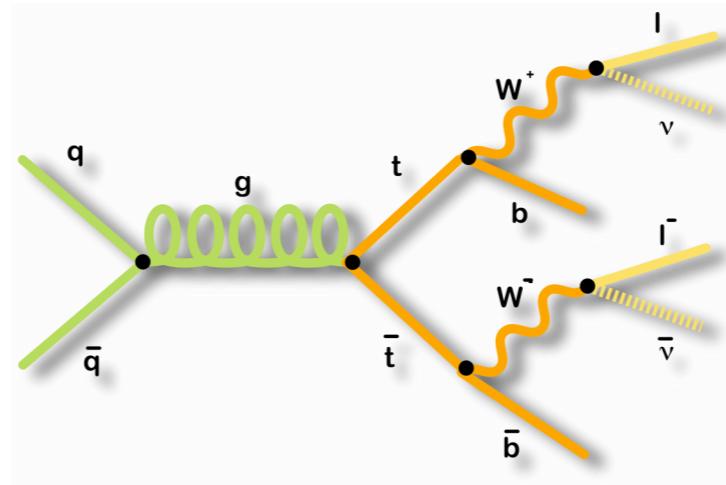
Measurement in different decay channels

- Important to check consistency between channels (is it SM top?)
- Discrepancy could indicate new physics

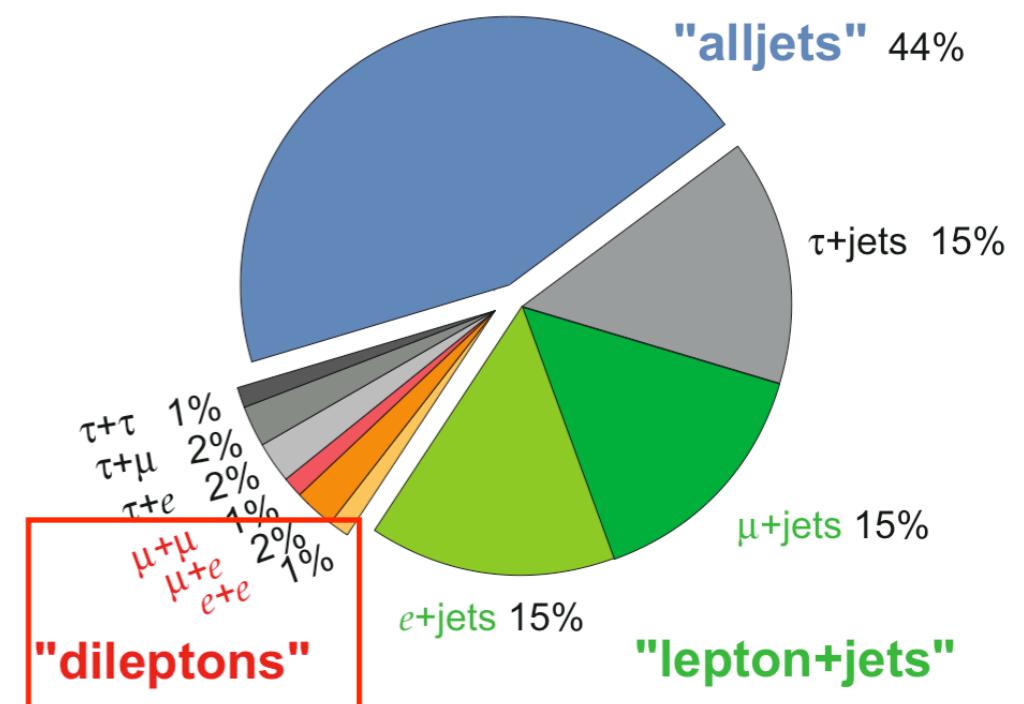


Dilepton decay channel

- 2 leptons, 2 jets, large missing E_T
- Mostly electroweak background
 - Drell-Yan, Diboson
 - Instrumental background (fakes)
- Kinematically underconstrained
 - Two neutrinos
 - Make assumptions and integrate over at least one variable



Top Pair Branching Fractions



Disadvantages

- Low statistics
- 2 vs escape undetected— underconstrained system

Alljets decay channel

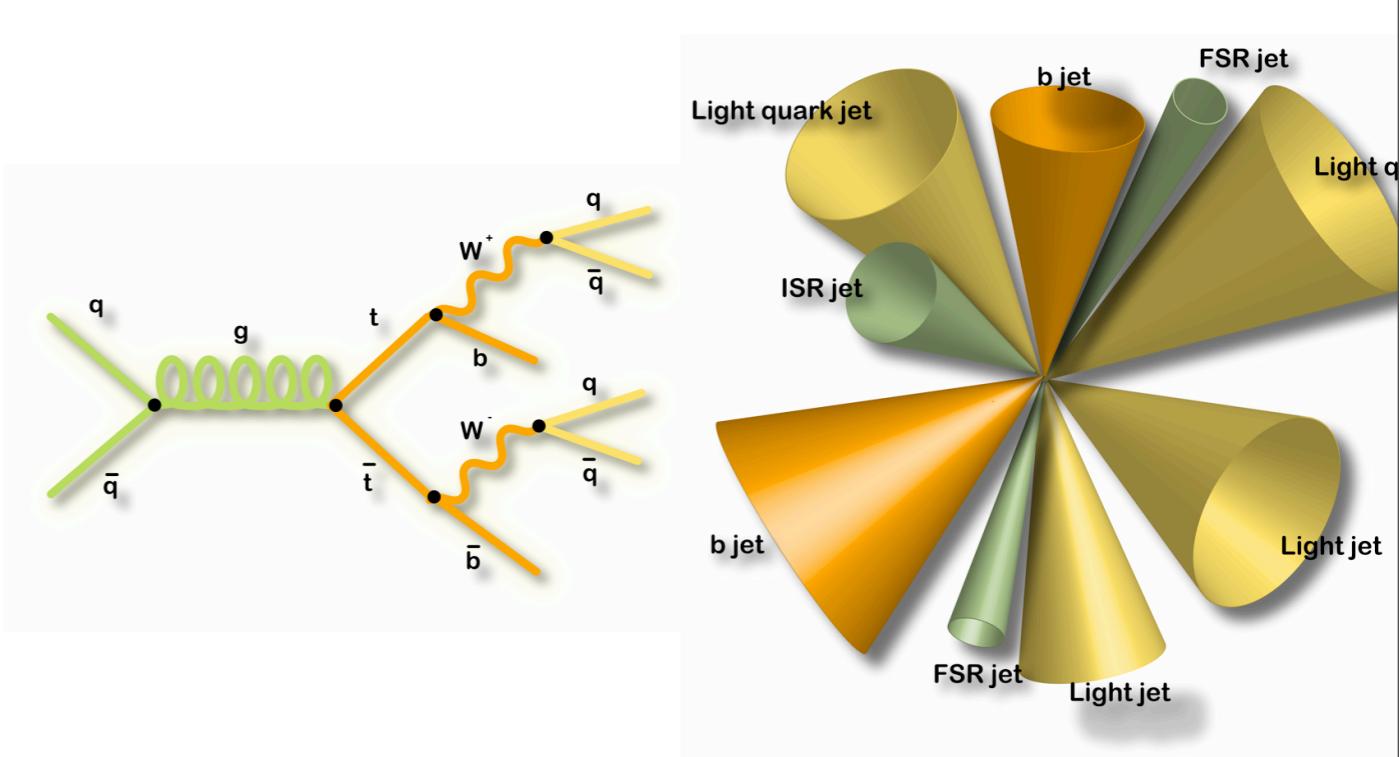
- Look for 6 jets
 - Dominated by QCD multijet background
 - Require b-tags to have appreciable signal
- Reconstructable final state
 - Many permutations of jet combinations

Advantages

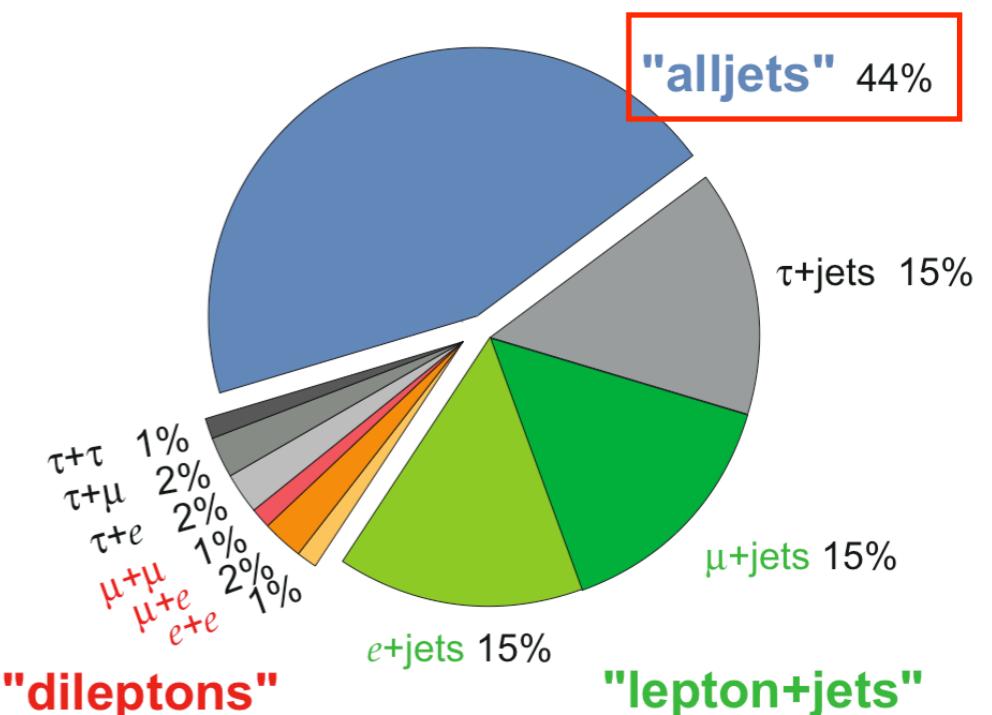
- High statistics
- Hadronic Ws allow for *in situ* jet energy scale (JES) calibration as in l+jets channel

Disadvantages

- Large background

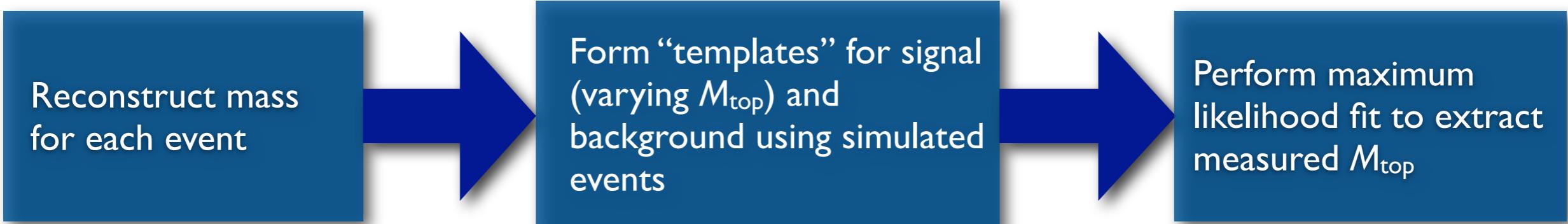


Top Pair Branching Fractions



Reconstructing the mass

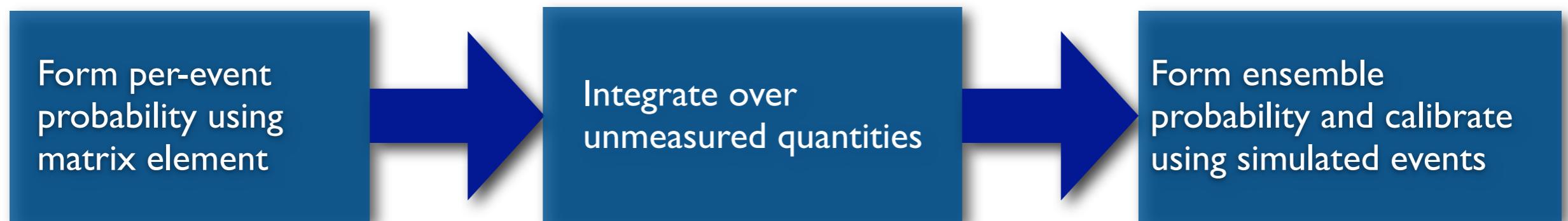
I. Template-based



Advantages: Less CPU bound (systematic uncertainties less likely to be limited by CPU)

Disadvantages: Only single number (recon. mass) per event in final Likelihood, all events have equal weight

2. Matrix Element-based



Advantages: More statistical power, probability curve rather than single mass per event, events weighted naturally

Disadvantages: Complex numerical integration (much CPU)

Cut-based event selection: dilepton channel

- Two well-identified leptons
 - Lower statistics
 - Better signal purity
- “Lepton+track”
 - 2nd lepton is only required to be an isolated track
 - More statistics at expense of background

Source	CDF	DØ
$t\bar{t}$ ($M_t=175 \text{ GeV}/c^2$)	164.3 ± 5.1	86.9 ± 3.8
Drell-Yan	50.1 ± 7.2	12.8 ± 1.4
Fakes	81.0 ± 15.9	7.1 ± 1.2
WW/WZ	15.4 ± 1.0	4.0 ± 0.6
Total	311.8 ± 18.7	110.8 ± 5.0
Data	330	107
<i>Expected Signal Fraction</i>	53%	78%

CDF [lepton+isolated track]

- 1 lepton with $p_T > 20 \text{ GeV}/c$
- 1 isolated, well-measured track with $p_T > 20 \text{ GeV}/c$
- 2 jets with $E_T > 20 \text{ GeV}, |\eta| < 2$
- $E_T > 25 \text{ GeV}$



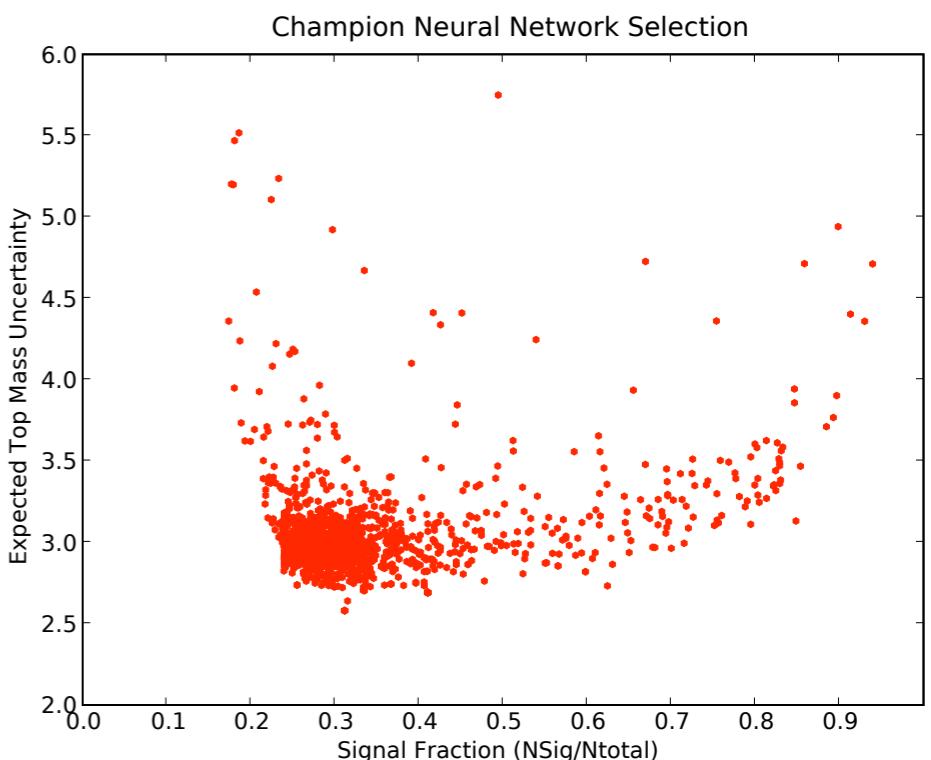
DØ [two identified leptons]

- 2 leptons with $p_T > 15 \text{ GeV}/c$ electrons up to $|\eta| < 2.5$
- 2 jets with $p_T > 20 \text{ GeV}/c, |\eta| < 2.5$
- $H_T > 115 \text{ GeV}$



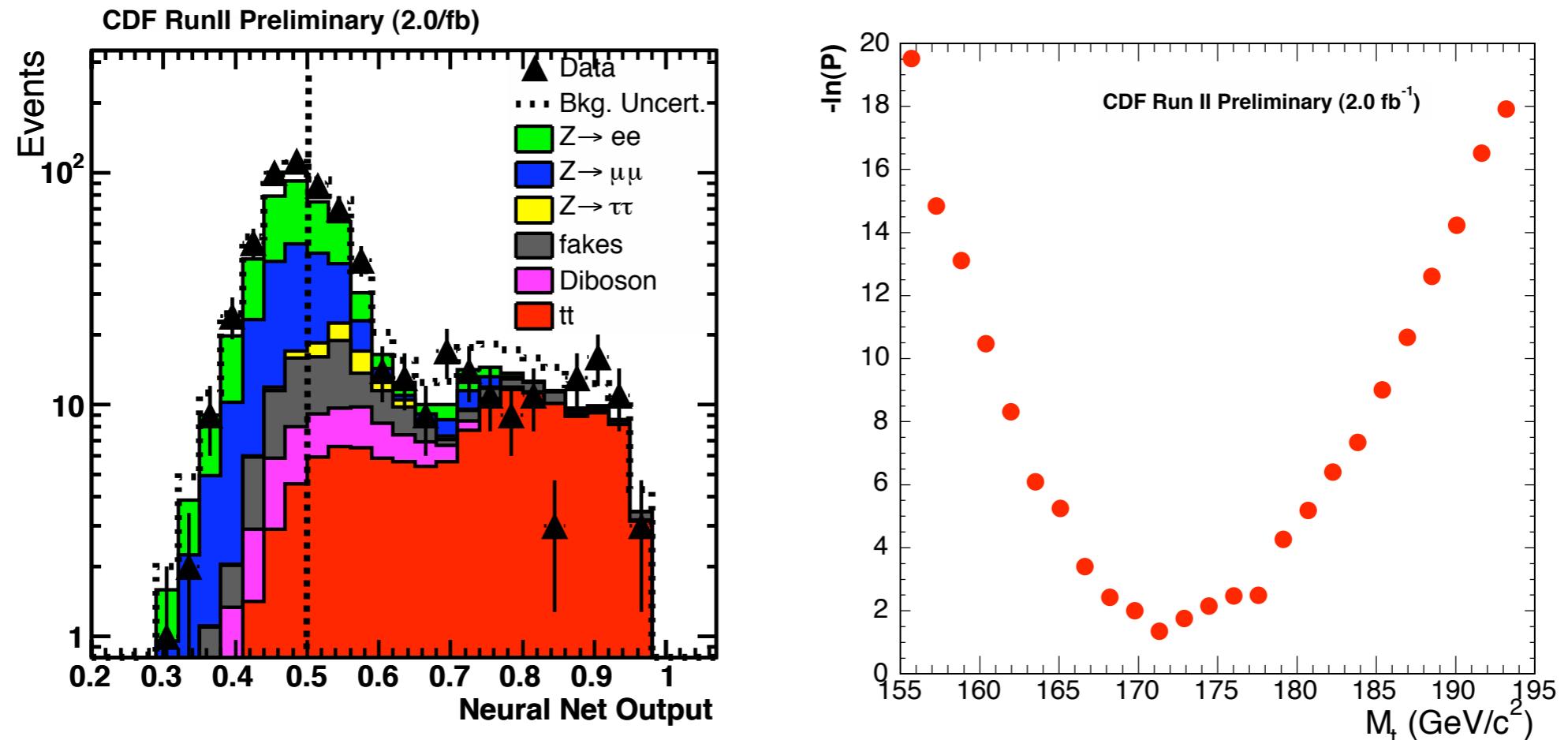
Advanced event selection: ENN

- Most selections used in top mass measurements were designed for x-section measurements
 - Optimized for S:B
- Devise selection optimized for uncertainty in top mass
 - Evolutionary neural net
 - Evaluate “fitness function” (M_t stat. error from pseudoexperiments)
 - Select best networks and breed
 - Best networks do not have best S:B
 - 20% improvement in CDF ME analysis over cut-based selection



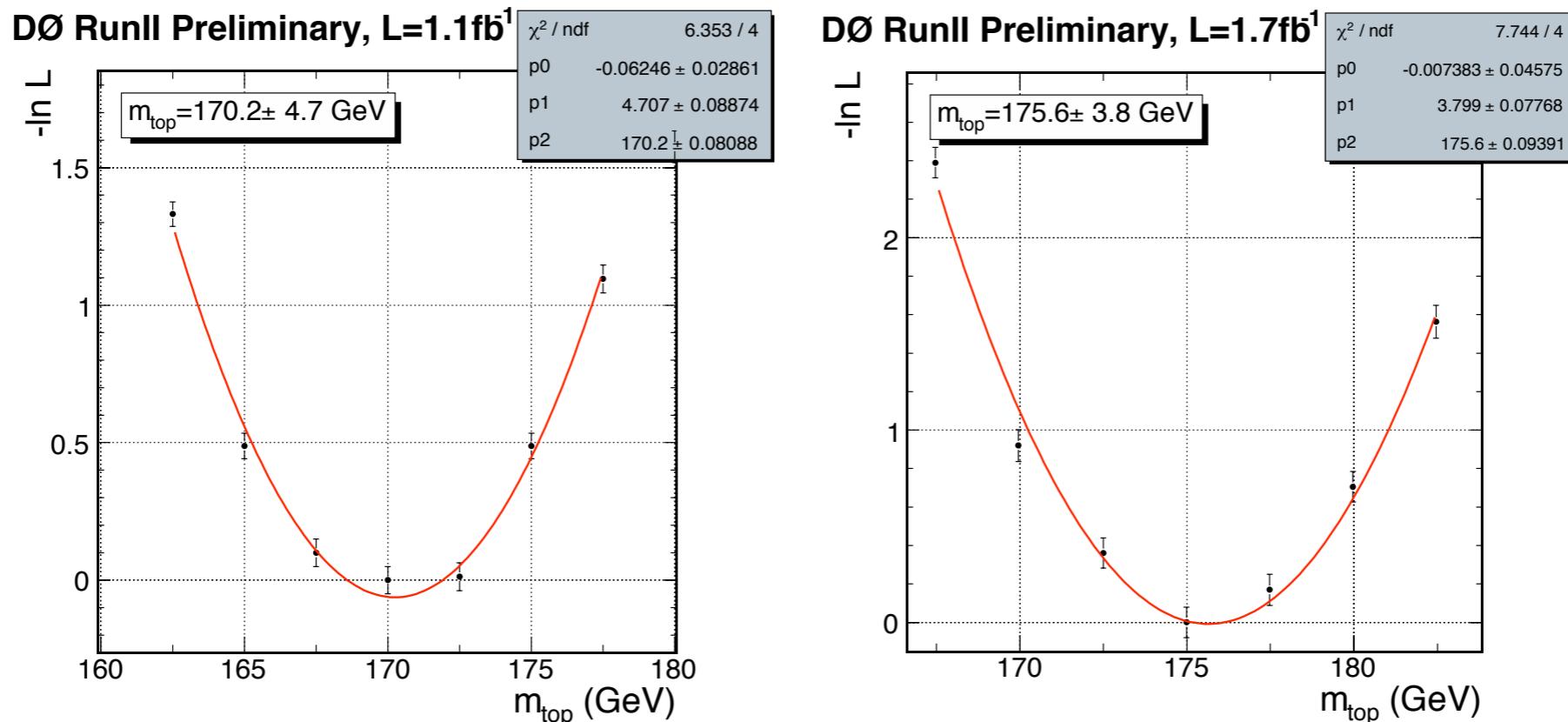
Source	CDF(ME)
$t\bar{t}$ ($M_t=175 \text{ GeV}/c^2$)	121.8 ± 7.5
Drell-Yan	128.1 ± 14.3
Fakes	33.5 ± 5.9
Diboson	18 ± 3.7
$Z \rightarrow \tau\tau$	12.1 ± 2.6
Total	313.3 ± 21.2
Data	344

Matrix element dilepton mass: CDF



- Matrix element probabilities for both signal and dominant backgrounds
- Use sample selected using evolving neural net
 - 2.0 fb^{-1} (344 events)
- Measure $M_t = 171.2 \pm 2.7(\text{stat.}) \pm 2.9(\text{syst.}) \text{ GeV}/c^2$

Matrix element dilepton mass: DØ

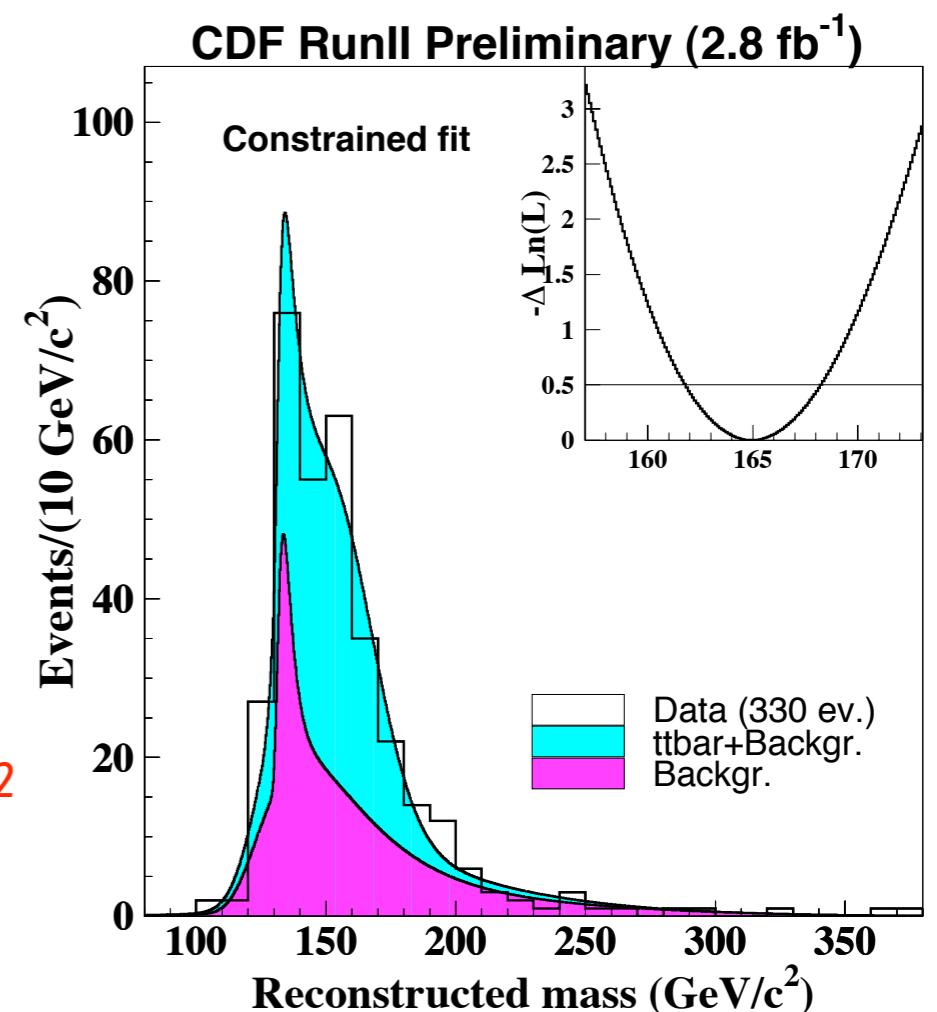


- Measurement performed in $e\mu$ channel only
 - Reduces Drell-Yan background
 - Expect 87 $t\bar{t}$ events out of 107 data events
- Uses 2.8 fb^{-1} of data
- Measure $M_t = 172.9 \pm 3.6(\text{stat}) \pm 2.3(\text{syst}) \text{ GeV}/c^2$

Template dilepton mass: CDF



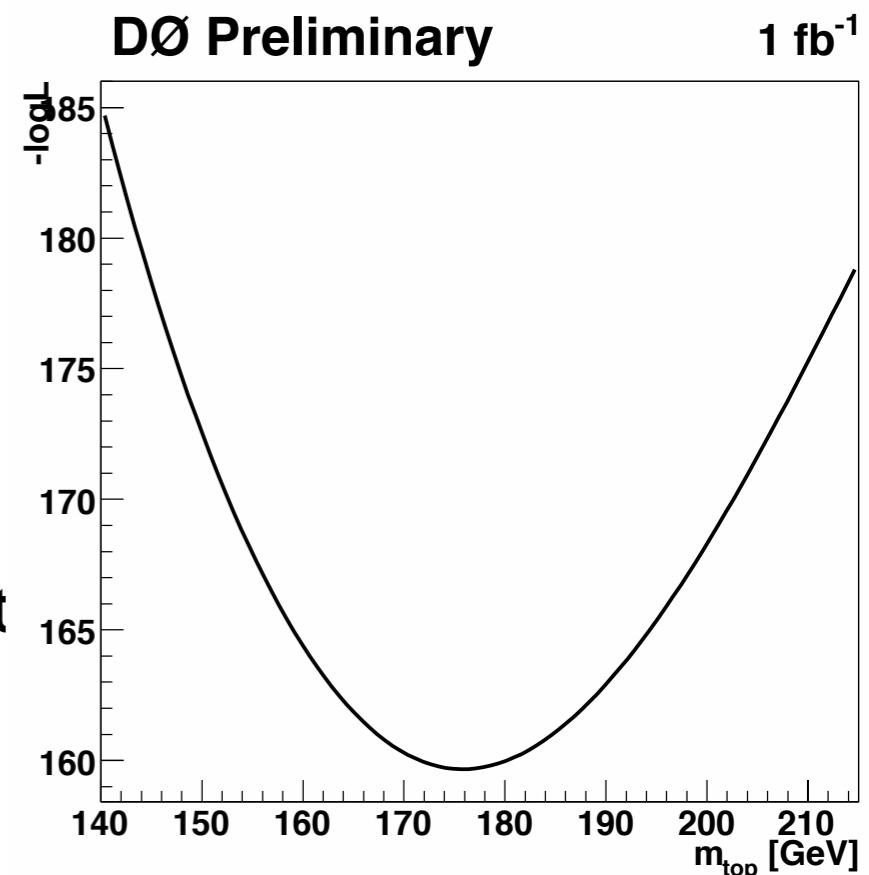
- Template method integrating over neutrino ϕ
 - Combined background template
- Use lepton+isolated track sample
- Use 2.8 fb^{-1} of CDF data
 - Measure $M_{\text{top}} = 165.1^{+3.3}_{-3.2}(\text{stat.}) \pm 3.1(\text{syst.}) \text{ GeV}/c^2$



Template dilepton mass: DØ



- Template method integrating over neutrino rapidity
- Include looser lepton+track selection
- Measure $M_t = 176.0 \pm 5.3(\text{stat.}) \pm 2.0(\text{syst.}) \text{ GeV}/c^2$
- Combine all Run II measurements of dilepton mass at DØ
 - Matrix Element eμ and Template ee, μμ, and l+track
 - $M_t = 174.4 \pm 3.2(\text{stat.}) \pm 2.1(\text{syst.}) \text{ GeV}/c^2$
 - $\chi^2/\text{dof} = 1.3/3$



Systematics: dilepton channel

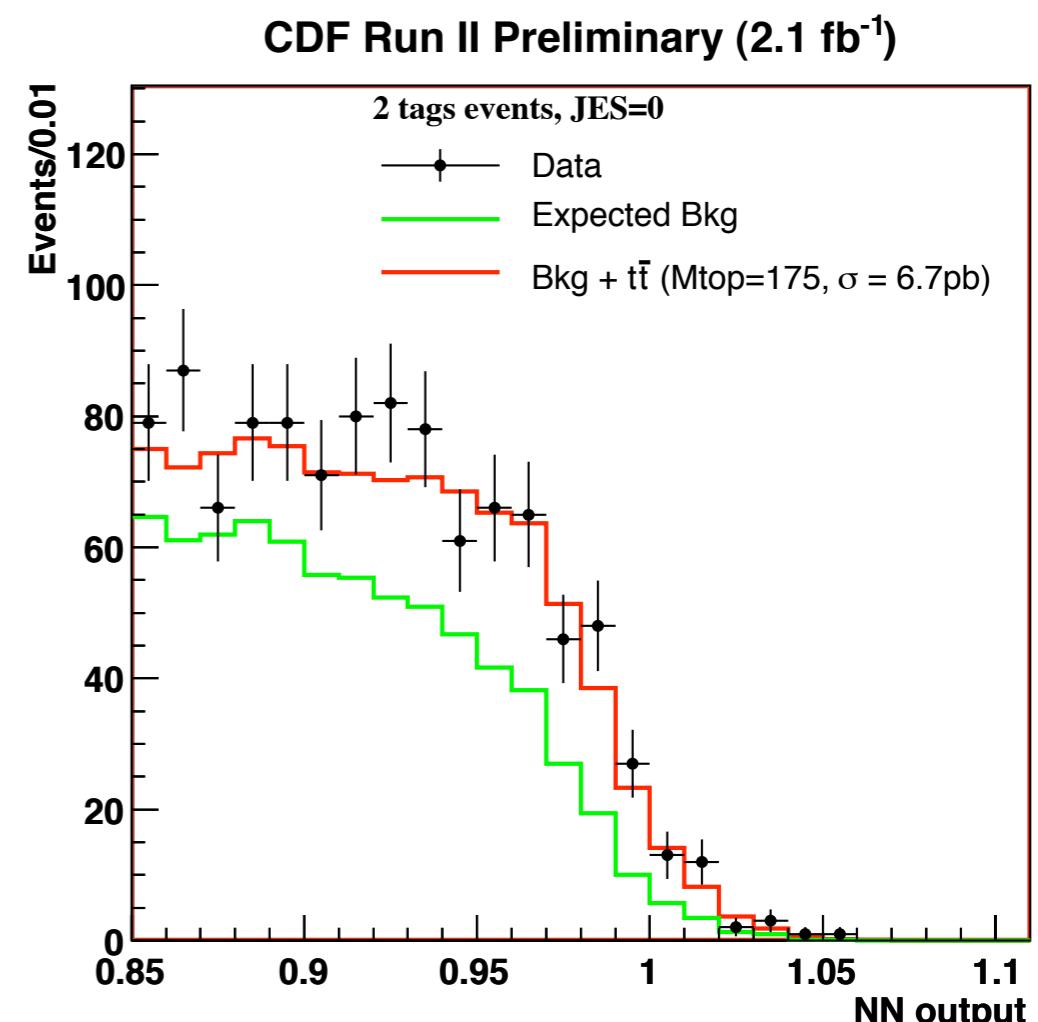


Source	CDF (ME) GeV/c ²	CDF (Template) GeV/c ²	DØ(ME) GeV/c ² [Run IIb only]	DØ(Template) GeV/c ²
Jet Energy Scale	2.5	2.9	2.3	1.7
b Jet Energy Scale	0.4	0.4	0.3	0.5
Pileup	0.2	0.2	—	—
MC Statistics	0.5	—	—	0.1
PDFs	0.6	0.3	0.2	0.3
Generator	0.9	0.2	—	0.8
Background Shape	0.2	0.5	—	0.3
QCD Radiation	0.5	0.3	0.4	0.1
Method	0.4	—	0.4	0.8
Sample Composition	0.3	0.5	0.3	0.3
Lepton Resolution	0.1	0.3	0.3	0.1
Total	2.9	3.1	2.5	2.0

- Systematic uncertainty in dilepton channel is dominated by JES error
 - Cannot do *in situ* calibration

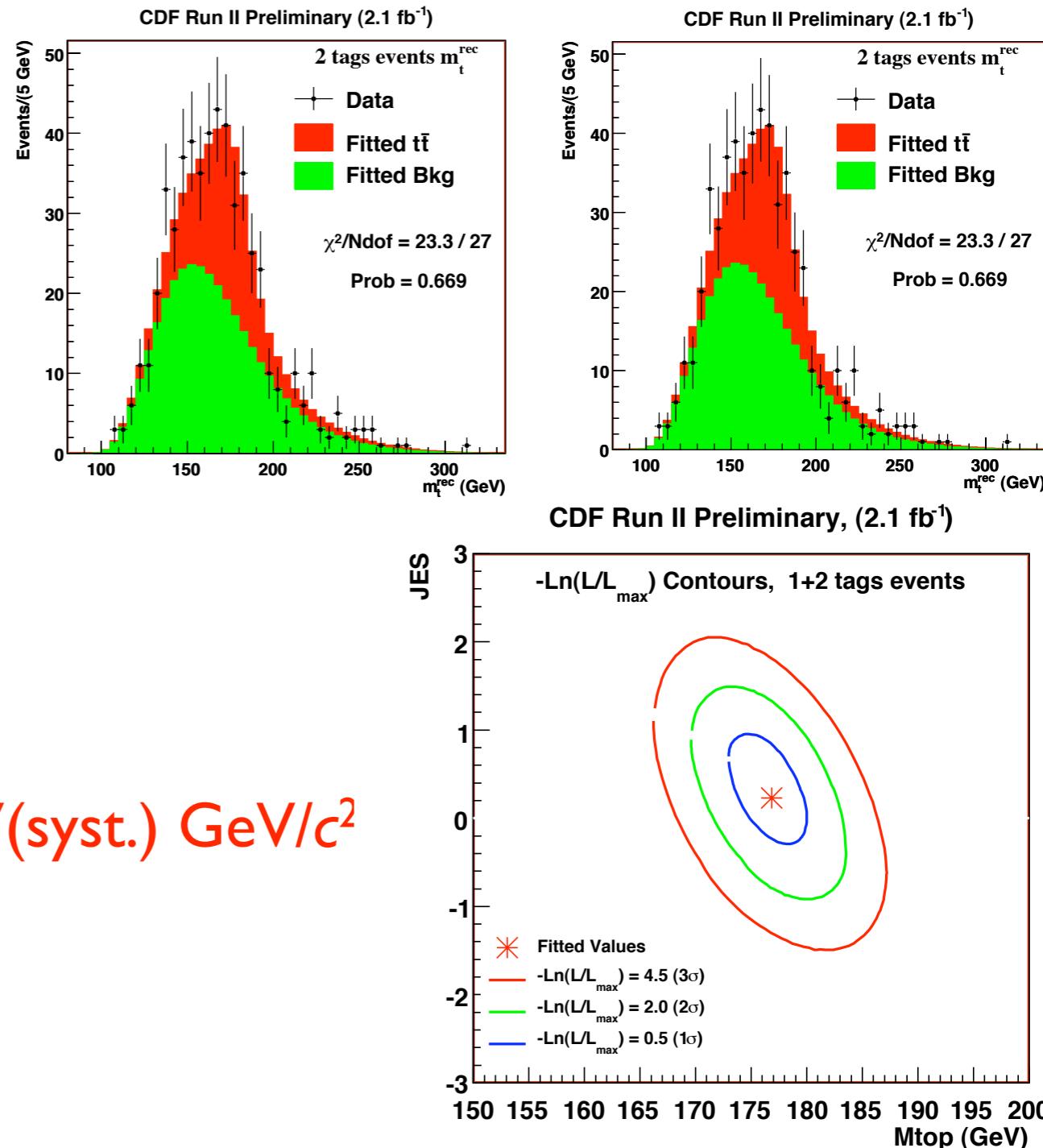
Event selection: all jets channel

- Initial cuts
 - 6-8 jets with $E_T > 15$ GeV
 - Enforce minimum distance between jets
 - Veto events with well measured leptons
 - Require b -tags
 - Apply NN to further reduce background
 - Model background using data
 - Expected background
 - 2409 ± 68 for 1-tag
 - 338 ± 28 for 2-tag
 - In data, 2881 1-tag events and 537 2-tag events



Template all hadronic mass: CDF

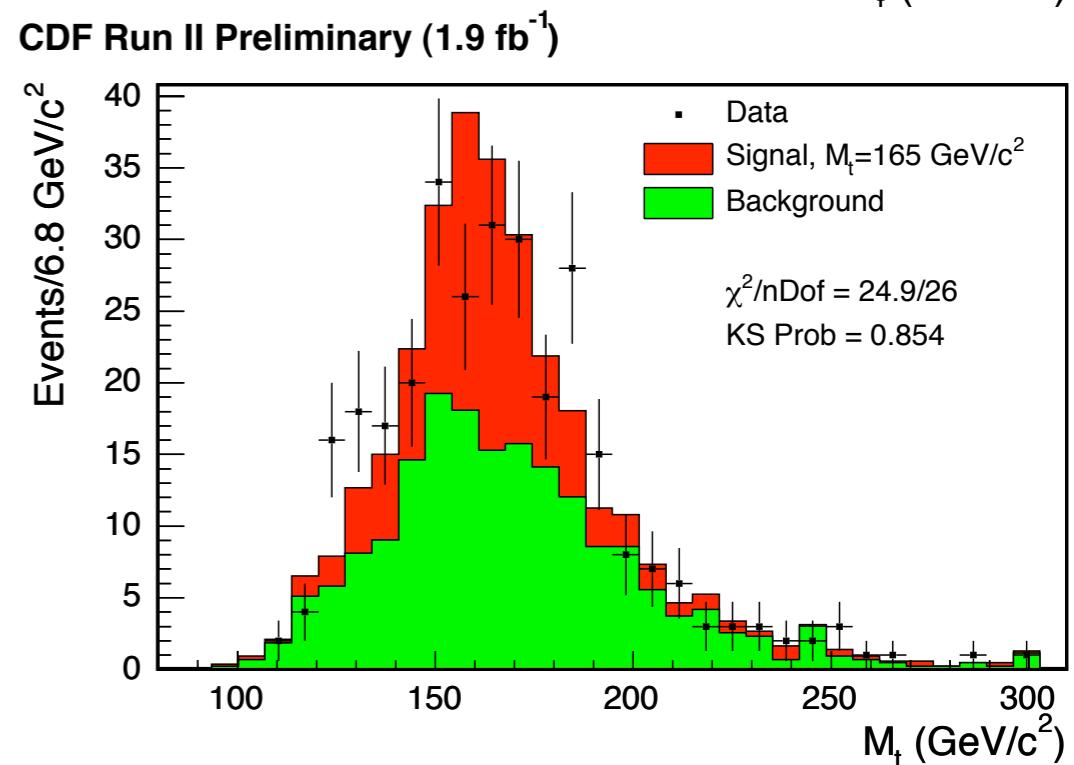
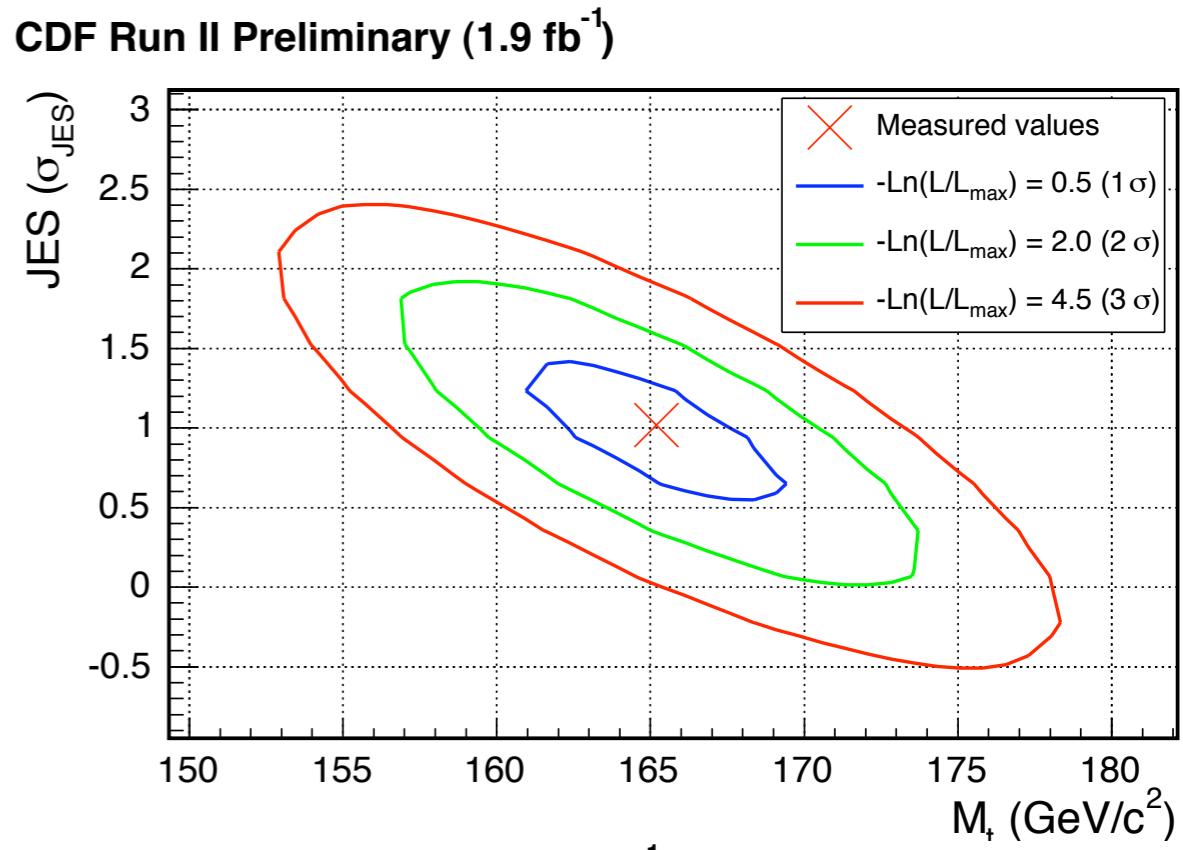
- Separate signal into 1 and 2-tag bins
- Single background template
 - Data-based model
- Simultaneous fit of M_t and JES
- Uses 2.1 fb^{-1} of CDF data
 - Measure $M_t = 176.9 \pm 3.8(\text{stat.+JES}) \pm 1.7(\text{syst.}) \text{ GeV}/c^2$



Ideogram alljets: CDF



- Templates for signal and background constructed using per-event likelihoods
 - ME-like calculation for likelihoods
 - Signal purity is a free parameter
- Use 1.9 fb^{-1} of CDF data
 - $M_t = 165.2 \pm 4.4(\text{stat.+JES}) \pm 1.9(\text{syst.}) \text{ GeV}/c^2$



Systematics: alljets

Source	CDF (Template) GeV/c²	CDF (Template) [JES]	CDF(Ideogram) GeV/c²
Residual Jet Energy Scale	0.8	N/A	0.7
b Jet Energy Scale	0.6	0.09	0.3
Pileup	0.3	0.03	0.7
MC Statistics	1.1	0.05	0.1
PDFs	0.4	0.11	0.4
Generator	0.5	0.26	0.8
Background Shape	N/A	N/A	0.4
ISR/FSR	0.5	0.10	1.2
Method	0.5	0.12	0.2
Sample Composition	N/A	N/A	0.5
Total	1.7	0.36	1.9

- Alljets channel systematics lower since JES is handled *in situ*

Impact and conclusions



- 2.8/fb combination from July 2008
 - Includes dilepton: CDF(ME), D0(combined)
 - Includes template alljets
- Dilepton and alljets measurements contribute ~12% weight
- Compare measurements across channels
 - Agree... for now.
- Both CDF and D0 continue analyses in these channels
 - Alljets result from D0 imminent

